



Technical Decision Analysis for the Potential Use of Passive Diffusion Bag Samplers for Long-Term Monitoring

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**Prepared by
The Interstate Technology and Regulatory Council
Diffusion Sampler Team**

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Technical Decision Analysis for the Potential Use of Passive Diffusion Bag Samplers for Long-Term Monitoring

Introduction—Application and Scope

The application of polyethylene passive diffusion bag (PDB) samplers in groundwater sampling is expanding and evolving. Research and testing of this new sampling method against more conventional groundwater sampling approaches is ongoing. The results of this work to date indicate that PDB samplers can be used to collect water samples for the analysis of volatile organic compounds (VOCs) listed in Table 1 of this document. Although there are other passive samplers that can collect environmental samples, this document discusses only the use of water-filled, polyethylene PDB samplers for collecting groundwater for VOC analysis.

PDB samplers are probably unsuitable for most initial site investigations or other exploratory type sampling where the range and type of contaminants are not reasonably well known and understood. If the groundwater contamination includes non-VOCs at concentrations that might be of regulatory interest, then PDB samplers may not be capable of providing full coverage of the analytes of interest. In this case, a more conventional groundwater sampling approach is recommended.

Decision Analysis for Using PDB samplers for Groundwater Monitoring of VOCs

The series of questions presented below is intended to enable someone to quickly screen sites and to decide whether PDB samplers might be suitable. Before deployment of PDB samplers, it is recommended that, at a minimum, the questions in the decision tree be answered, the use of PDB samplers be discussed with the regulators, and a cost comparison be completed. The cost analysis should include the cost of all laboratory or field tests during any period of overlap between conventional sampling and use of PDB samplers.

Acronyms Used

ITRC = Interstate Technology Regulatory Council
PDB = passive diffusion bag
POC = point of contact
SVOC = semivolatile organic compound
VOC = volatile organic compound

Decision Analysis for Potential Use of PDB Samplers

1. Is sampling being done for long-term groundwater monitoring?

- *Yes—Go to #2.*
- *No—Stop. Consider use carefully.*

To date, the recommended use of PDB samplers has been for long-term monitoring of groundwater plumes where specific VOCs are the sole target analytes. PDB samplers also have been shown to be an effective tool for characterization of vertical VOC stratification in the screened or open intervals of wells when (1) coupled with borehole flowmeter data and (2) the VOCs are known to be quantifiable using PDB samplers. More study is needed before the technology is used for other purposes. This document is focused on the use of PDB samplers for long-term monitoring.

2. Have the groundwater contaminants at the site been fully characterized?

- *Yes—Go to #3.*
- *No—Stop. Consider use carefully.*

PDB samplers should be used for sampling only VOCs and a few other chlorinated and aromatic compounds because of the diffusive properties of these compounds. Their use should be restricted until the site has been characterized using conventional groundwater sampling methods and there are sufficient data to demonstrate that specific VOCs are the only analytes of concern or there is sufficient and conclusive site knowledge to state that VOCs are the only possible target analytes.

3. Is groundwater sampling at the site focused on VOCs?

- *Yes—Go to #4.*
- *No—Stop. Do not deploy without alternative plans.*

The ability of a compound to diffuse into the PDB is essential, and most non-VOCs will not meet this criterion. PDB samplers are not suitable for collecting metals or SVOCs. Therefore, it is inappropriate to use this technology for such analytes.

4. Can all target analytes at the site be expected to be taken up by PDB samplers (Table 1)?

- *Yes—Go to #5.*
- *No—Stop. Consider use carefully.*

Although most VOCs diffuse well through polyethylene, some do not or have not been properly tested and are therefore not recommended for PDB sampling at this time. Appendix Table 1 also lists compounds that have been (or are planned to be) the subject of field tests. Reports found on the ITRC Diffusion Sampler Information Center (<http://diffusionsampler.itrcweb.org/>) may provide information on the suitability of PDB samplers for these compounds. Contact ITRC to determine whether there are any ongoing or planned studies for these compounds. Further laboratory or field studies may be necessary before using PDB samplers for these compounds as well as for compounds not listed in the

5. Is groundwater temperature expected to be >10°C (50°F) during all sampling events?

- *Yes—Go to #6.*
- *No—Further study may be necessary.*

The equilibration time for PDBs is temperature dependent. Although 14 days is a sufficient period in most instances, there are no equilibrium data for water temperatures below 10°C (50°F). Equilibration of the PDB samplers will be slower in cold water and longer equilibration times may be necessary. A field test should be conducted to demonstrate that temperature is not a significant factor. As a point of reference, groundwater temperatures are generally about 1–2°C above mean annual air temperatures.

6. Have you discussed the potential use of PDB samplers with regulators?

- *Yes—Go to #7.*
- *No—Stop. Discuss use of PDB samplers with regulators before deployment.*

Existing regulatory permits, consent orders, and other agreements may contain model language and/or sampling and analysis plans that stipulate a specific methodology for the collection of groundwater samples. In addition, agency guidance documents may also state a preference for a specific sampling methodology. Discussions with regulators should be held prior to the decision to deploy PDB samplers to determine whether alternative technologies will be acceptable. Significant negotiations may be needed to modify or amend permits, orders, and sampling plans, and in some instances public meetings may be required. The overhead costs of these negotiations should be considered in the decision process.

7. Are the site regulators familiar with the PDB sampling technology, and will they allow the data to be used for the same purposes as those obtained by conventional sampling?

- *Yes—Go to #8.*
- *No—Stop. Weigh cost and time factors before proceeding.*

Regulators are likely to require some comparative sampling to provide evidence that the use of PDB samplers is valid at a particular site. If these requirements are extensive, costly, and burdensome, there may be no advantage to using PDB samplers. There may be reasons to employ PDB samplers in such an instance, but more information would be needed to evaluate specific situations. The ITRC State POC can serve as a technical resource for regulatory personnel within their own state and may be able to assist them in evaluating requests to apply PDB samplers to specific sites. Information is provided on the ITRC Diffusion Sampler Information Center (<http://diffusionsampler.itrcweb.org>).

8. Are the monitor wells to be sampled in an area where there is sufficient groundwater velocity (>0.5 ft/day)? Low groundwater velocity can result from either a low hydraulic conductivity (<10⁻⁵ cm/sec) or a low hydraulic gradient (<0.001).

- *Yes—Go to #9.*
- *No—Stop. Wells will need to be evaluated individually for PDB samplers.*

PDB samplers require sufficient groundwater flow to provide equilibration with the aquifer. This will not occur where groundwater is stagnant or the well has a low yield. Volatilization of VOCs in such wells may exceed the rate of replacement from groundwater flow. Wells with sustained yields of <100 mL/min have not been tested using PDB samplers, but all existing technologies have shortcomings in this type of environment. It is difficult to collect a water sample in low-permeability zones using any type of device, and PDB samplers may provide a practical approach if the restrictions are carefully considered.

9. Are monitor wells currently free of dedicated pumps or other sampling equipment?

- *Yes—Go to #10.*
- *No—Stop. Consider cost of removal*

Dedicated pump systems (low flow or other) are employed at some sites to reduce costs at frequently sampled wells as they eliminate the needs to decontaminate sample equipment and to collect many types of sample blanks. Although dedicated pumps have high initial costs, they may last up to 20 years and save money over that extended period. However, PDB samplers might be more cost effective than dedicated pump systems if the pumps can be used elsewhere, if the pumps are near the end of their life cycle, or where the groundwater characteristics significantly reduce their expected life. Replacement with PDB samplers might be considered on a graduated basis, as old pumps need to be replaced.

10. Has a cost analysis shown PDB samplers to offer a cost savings compared to current sampling techniques?

- *Yes—PDB sampling appears to be a viable alternative.*
- *No—Stop. Retain existing sample collection program.*

A primary driving force in the use of PDB samplers is that it can be much less expensive than pump and sample technologies. A cost analysis is necessary to estimate whether savings will result from the deployment of PDB samplers in a specific situation. Remember to include in the cost analysis all laboratory or field tests that are likely to be required in a comparison study.

The largest cost savings related to the use of PDB samplers are in (1) personnel time on site and (2) the collection and disposal of purge water from sampling and the handling and disposal of water and other fluids used in the decontamination of portable sampling systems. The size of the operation will affect the cost savings. The cost for disposing of contaminated water and other liquids is site-specific because some sites have their own treatment facilities on site. Sites that incur large costs because of off-site disposal would be excellent candidates for PDB samplers even when only a modest number of wells are involved.

Table 1. Compounds Tested in the Laboratory and Analyzed in Field Trials Using PDB Samplers

Compound	Laboratory Study Results ¹		Field Test Data Available or Planned ²
	Favorable	Unfavorable	
Acetone		X ³	
Benzene	X		X
Bromodichloromethane	X		
Bromoform	X		
2-butanone			X
Chlorobenzene	X		X
Carbon tetrachloride	X		X
Chloroethane	X		X
Chloroform	X		X
Chloromethane	X		
2-chlorovinyl ether	X		
Dibromochloromethane	X		
Dibromomethane	X		
1,2-dichlorobenzene	X		X
1,3-dichlorobenzene	X		
1,4-dichlorobenzene	X		X
Dichlorodifluoromethane	X		
1,1-dichloroethane ³			X
1,2-dichloroethane	X		X
1,1-dichloroethene	X		X
<i>cis</i> -1,2-dichloroethene	X		X
<i>trans</i> -1,2-dichloroethene	X		X
Dichloropropane			X
1,2-dichloropropane	X		
<i>cis</i> -dichloropropene	X		
1,2-dibromoethane	X		
<i>trans</i> -1,3-dichloropropene	X		
Ethyl benzene	X		X
Freon 113			X
Isopropyl benzene			X
Methyl-iso-butyl ketone		X ³	
Methyl- <i>tert</i> -butyl ether		X	X
Methylene chloride			X
Naphthalene	X		X
Styrene		X	
1,1,2,2-tetrachloroethane	X		
Tetrachloroethene (PCE)	X		X
Toluene	X		X
1,1,1-trichloroethane	X		X
1,1,2-trichloroethane	X		X
Trichloroethene (TCE)	X		X
Trichlorofluoromethane	X		
1,2,3-trichloropropane	X		
1,2,4-trimethylbenzene			X
Vinyl chloride	X		X
Total xylenes	X		X

¹ Vroblesky, D. A., and T. R. Campbell (2001). Equilibration times, stability, and compound selectivity of diffusion samplers for collection of ground-water VOC concentrations, *Adv. Env. Res.*, **5**(1): 1–12.

² These compounds are present at sites where PDB samplers have been deployed or are planned. This listing does **not** imply favorable PDB results were found; individual reports must be consulted. More information is available at <http://diffusionsampler.itrcweb.org/>.

³ Sivavec, T. M., and S. S. Baghel (2000), General Electric Company, written communication.

Decision Analysis Summary

A negative answer to any of the following questions will require further action or investigation before PDB samplers can be deployed. If all answers are affirmative, PDB sampling is likely to be a viable option for the site.

Question	YES	NO
1. Is sampling being done for long-term groundwater monitoring?		
2. Have the groundwater contaminants at the site been fully characterized?		
3. Is groundwater sampling at the site focused on VOCs?		
4. Can all target analytes at the site be expected to be taken up by PDB samplers (Table 1)?		
5. Is groundwater temperature expected to be >10°C (50°F) during all sampling events?		
6. Have you discussed the potential use of PDB samplers with regulators?		
7. Are the site regulators familiar with PDB sampling technology, and will they allow the data to be used for the same purposes as those obtained by conventional sampling?		
8. Are the monitor wells to be sampled in an area where there is sufficient groundwater velocity (>0.5 ft/day)? Low groundwater velocity can result from either a low hydraulic conductivity (<10 ⁻⁵ cm/sec) or a low hydraulic gradient (<0.001).		
9. Are the monitor wells currently free of dedicated pumps or other sampling equipment?		
10. Has a cost analysis shown PDB samplers to offer a cost savings compared to current sampling techniques?		

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PDB = passive diffusion bag
VOC = volatile organic compound